ADDITIONAL FEE:

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REMARKS

The Office Action issued January 11, 2011 has been received and its contents have been carefully considered.

Claims 1-7 are pending in this application. Claim 1, which defines a secondary ion mass spectrometer (SIMS), and claim 6, which defines a primary ion source for such a spectrometer, are independent. Claims 2-5 depend from claim 1 and claim 7 depends from claim 6.

Claims 1-7 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the U.S. Patent No. 6,989,528 to Schultz et al., in view of the U.S. Patent No. 3,508,045 to Liebl and Anderson (or, as stated in the heading, Anderson et al.) and further in view of U.S. Patent No. 4,426,582 to Orloff et al. This rejection is respectfully traversed.

The present invention, as defined both in claims 1 and 6, concerns a primary ion source, for use in a secondary ion mass spectrometer (SIMS), which generates a mass pure ion beam of Bismuth clusters Bi_n^P, where $n \geq 2$ (i.e. a cluster)

and p $\geq$ 1 (i.e. cluster of charged Bismuth ions). None of the references, taken individually or in combination, teach or suggest generating such an ion beam, or the use of such a ion beam in a SIMS.

As defined in this application and as known in the art, the term "efficiency" as it relates to secondary ion production from a bombarded sample, refers to the ratio between the amount of generated secondary ions and the consumed target/sample material. With the invention, this efficiency is improved by using mass pure Bi ion clusters as primary ions as compared, for example, to the use of Au_1^+ gold ions as primary ions.

Set forth below is a review of the state of the art at the time the present invention was made. This discussion first appeared in applicants' Amendment filed July 24, 2009, and is presented again here for the convenience of the Examiner.

General Background of the Invention

As general information for understanding the present invention, the following provides a brief introduction to the state of the art at the time the invention was made:

At the time of filing, the priority date of August 25, 2003, it was the state of the art to use clusters like Au_2 and Au_3 to increase efficiency over Au_1. This understanding is acknowledged on page 2, first paragraph, of the present specification. However, there is no evidence of the use of other metal clusters in SIMS to increase the efficiency of secondary ion generation.

There had been reports about ions (molecules, organic clusters) with lower mass, e.g. SF_5, C_nH_m, and higher mass, e.g. C_{60}, which showed efficiencies similar to or higher than Au gold clusters. However, the atomic mass of all their constituents (S, F, C, H) is lower than that of gold (Au). There is no report about higher efficiencies correlating with the mass of constituents if clusters were used.

The reason is that the generation of secondary ions by the sputtering of organic materials with primary ions is not as simple as is assumed by the Examiner. Not only is it necessary to take into account the energy transfer by the collisions, but also the chemical environment (the "matrix effect") and its modification by the implanted primary ions. However, the interaction of organic materials with energetic

cluster projectiles is not well understood and there are no rules that allow a prediction or extrapolation of the efficiency for a certain primary cluster based on the mass of its constituents, the number of constituents, and its total mass or ion charge. It is further not sufficient to evaluate the moderate differences in sputter yields. The ionization effects influenced by the matrix effect are by far more important, and these are not predictable in any way.

In addition, the performance of a cluster ion source (beam intensity, spot size) depends not only upon the intensity of the different cluster species emitted but also on their energy distribution, their angular distribution and their virtual source size.

In late 1970's, there were some basic studies made by Orloff and others on liquid metal ion sources comprising Bi. These researchers were interested in the basic emission characteristics of such liquid metal ion sources and measured the whole emitted ion beam without mass filtering; i.e., a mixture of atomic ions and clusters with different numbers of atoms and different charge states.

Van de Walle and others measured the mass spectrum of Bi and found some Bi cluster ions with substantial intensities.

None of these groups involved in this research on liquid metal ion sources gave any indication or hint of the use of such Bi cluster beams, not to mention their use in SIMS.

In particular, a person skilled in the art at the time of filing this application did not consider use of a Bi cluster source in SIMS for the following reasons:

1. Au (gold) was the de facto standard in SIMS as ion source.

2. It was not known whether Bi, compared to Au, had any beneficial or detrimental matrix effect due to its different chemistry, thereby influencing efficiency of secondary ion production.

3. The angle distribution of a Bi cluster ion beam was not known, nor was it known whether such a beam would have a sufficiently small focus on the target.

To summarize, at the time of filing this application, there existed some studies on the general characteristics of

Bi liquid metal ion source. But there existed no information about the suitability of such ion sources in SIMS. Some relevant parameters, i.e. angle distribution, matrix effect and chemistry of mass pure Bi clusters, were even not known at all.

<u>The Cited Prior Art</u>

<u>Schultz et al.</u>

Schultz et al. disclose a MALDI (matrix assisted laser desorption and ionization) mass spectrometer, wherein secondary ions are generated via laser desorption. This laser desorption is assisted by the matrix of the target to be sputtered. Schultz et al. propose to implant ionized clusters (Au, Al) from a liquid metal source into the matrix (near surface region) of the target in order to enhance laser desorption.

With the present invention, Bi ion clusters are directly used in SIMS for sputtering a target to be analyzed. This use of the primary ion beam is different from the use of primary ion beams in MALDI, wherein a <u>laser beam</u> (not a primary ion beam) is used to generate the secondary ions. In MALDI, a primary ion beam may be employed to <u>implant</u> ions into the target matrix, thereby modifying

the chemical characteristics of the target and improving laser ionization/desorption of target material. To repeat: the ion source taught by Schultz et al. is for implanting ions into the matrix as optical absorption sites for the laser light desorption.

Schulz et al. disclose, for the ion implantation into the matrix, that laser desorption of ions from matrices which were modified by the implantation of ions enhances the ion signal. However, Schultz et al. do not provide any information on target consumption. In contrast to the opinion of the Examiner, Schultz et al. does not disclose that the efficiency of ion generation increases with mass of the implanted primary ion.

To summarize, therefore, the patent to Schultz et al.

- concerns a totally different technology (MALDI) than the present invention;
- uses an assistive ion beam not as primary ion beam for sputtering but for matrix modification by ion implantation;
- does not show higher efficiency for higher mass of imp

- does not show any beneficial effect on efficiency by higher mass of sputtering primary ions; and
- does not disclose the use of Bi clusters.

A person skilled in the art and looking for an improvement in efficiency of secondary ion generation over the de facto standard Au in SIMS would not think to consult Schultz et al. Even if such a person did, he/she would not learn anything relevant to SIMS because the effect of matrix modification by implantation of metal ions would not reveal anything about the effects of specific ions as primary sputtering ion beam in SIMS.

Liebl et al. (Anderson et al.)

The Examiner contends that Liebl et al. teach that the mass of primary ions in SIMS should be as large as possible.

This reference in fact does refer to SIMS. Liebl et al. teach improving the sensitivity of SIMS, taking into account the generation and survival of the secondary ions (Col. 7, lines 41-49), in particular by using ions which have a large mass and are chemically highly reactive, -- i.e., ions of high electronegativity -- as primary ions.

The predominance of the electronegativity for high yields of secondary ions is stressed in Col. 8, lines 24-41.

As noted there, Fig. 7 discloses that the relative ion yield increases with electronegativity of the ion, the electronegativity being highest for the iodine ion. A comparison with Ar and Xe in Fig. 7 shows that it is the greater chemical reactivity (higher electronegativity), and not the larger mass of the primary ion, which leads to higher secondary ion yield. Thus, Liebl et al. confirm that the chemical characteristics of the primary ion are much more relevant than the mass of the ion when bombarding a sample in SIMS.

Bi has a lower electronegativity than Au. According to the teaching of Liebl et al., no improvement of ion yield would be expected or could be anticipated by replacing Au with the inventive Bi-clusters of lower electronegativity.

Taking Liebl et al. into account, a person skilled in the art would have rather used iodine clusters instead of Au as a primary sputtering ion beam in order to improve secondary ion yield, since Liebl et al. demonstrate superior yield for iodine.

The Examiner contends that Liebl et al. show an enhancement of efficiency of secondary ion generation with mass of the primary ion. This is not entirely correct. In

general, with higher mass, the consumed target increases in parallel with the number of generated secondary ions so that the efficiency does not change.

As noted above, Liebl et al. demonstrate that it is mainly the chemical characteristics of primary ions which make them suitable for SIMS, rather than their mass. Further, Liebl analyzes the yield for different primary ions in only those cases where the ions are monoatomic. The equation in Col. 8, line 12, showing an influence of the mass M_1 of the primary ion is only valid for monoatomic primary ions and not for primary ion clusters as are used in the present invention.

Liebl et al. thus tend to guide the person skilled in the art <u>away</u> from the present invention. Liebl et al. suggest using primary ions with high electronegativity rather than increasing the mass of the constituents of the primary projectile clusters.

In summary, Liebl et al. provide evidence of the fact that secondary ion generation in a target depends much more on the <u>chemistry</u> of the primary ion than on features like <u>mass and charge state</u>.

To recap, therefore, the patent to Liebl et al.:

- does not disclose or suggest a liquid metal ion source;
- does not disclose or suggest uses of Bi as ion source;
- does not disclose or suggest use of mass pure Bi-clusters in SIMS;
- suggests using highly electronegative ions as primary ions;
- confirms the importance of the chemical characteristics of a primary ion for high secondary ion yield; and
- does not disclose any advantage of a higher mass of primary ions for efficiency of secondary ion production.

Orloff et al.

According to the Examiner, Orloff et al. teach the use of a Bi liquid metal ion source for producing high current, medium energy, Bi ion beams.

In fact, Orloff et al. teach a liquid metal ion source for use in surface analysis using an electrostatic lens system. As noted above, they do not mention SIMS technology.

According to Orloff et al., the energy spread ΔE of the primary ion beam is highly relevant for achieving a well focused beam spot for analysis. Orloff et al. disclose the

use of a Ga liquid metal source together with a specific lens system.

Throughout this reference, Orloff et al. use a Ga liquid metal ion source with an energy spread at optimum condition of 5.3 eV. Ga has a mass of 69 u and a melting temperature of T = 303 K.

In contrast, Bi has a much higher mass (m = 209 u) and a much higher melting temperature (T = 544 K).

Since the energy spread, and thus the ability to focus, of a liquid metal source depends proportionally to the mass of the ion and the temperature of the liquid metal, Bi has serious disadvantages over Ga for use in surface analysis.

Thus, Orloff et al., which is most concerned with small target spot areas, would suggest using a Ga liquid metal ion source instead of a Bi liquid metal ion source.

The statement in col. 10, line 16, that liquid Bismuth generates results "entirely analogous to the results described before", refers to the electrostatic optical system developed and described by Orloff et al. for focusing ion beams. This phrase should not be understood to mean that Bi could provide beam parameters (energy spread, spot

size, efficiency etc.) that are as good as a Ga ion source. This is simply not the case.

The patent to Orloff et al. therefore fails to teach:

- using a Bi liquid metal ion source in SIMS;
- using clusters as primary ions;
- using a filter to generate a mass pure primary ion beam;
- that Bi clusters according to the invention are superior over Au_1^+ in efficiency of secondary ion generation.

To summarize, Orloff et al. would not guide a person skilled in the art, who knows about the energy spread and spot size of Ga and Bi, to use mass pure Bi clusters for sputtering in SIMS. Further, Orloff et al. simply do not provide any teaching of the composition and characteristics of different species in a Bi beam emitted from a Bi liquid metal ion source.

<u>The Combination of References under 35 U.S.C. 103(a)</u>

In the outstanding Office Action, the Examiner contends that applicants failed to provide any argument directed against the combination of Schultz et al, Orloff et al. and Liebl et al., citing <u>In re Keller</u> and <u>In re Merck et al.</u>

"Applicants' arguments filed 3-29-2010 were directed against each prior art reference individually."

However, it has been held that a prior art reference must either be in the field of applicant's endeavor or, if not, then be reasonably pertinent to the particular problem with which the applicant was concerned, in order to be relied on as a basis for rejection of a claimed invention. In re Oetiker, 977 F.2d 1443 (Fed, Cir. 1992). In the present case, none of the references is concerned with the problem of increasing the efficiency of secondary ion production in SIMS.

On page 5, lines 1-3, the Examiner concedes that Schultz et al. "fail to disclose bombarding the sample with Bismuth ions to increase the efficiency of secondary ion production from the sample, relative to bombardment of the sample with Au ions." As the Examiner understands, Schultz et al. are concerned with yield, not efficiency.

The Examiner then points to a passage in Liebl et al, Col. 7, lines 44-46, which states:

> "To generate the maximum number of secondary ions, the mass of the primary ions should be as large as possible."

The Examiner overlooks that Liebl et al. clearly teach, in Col. 7, lines 41 to 59, "to take into account both the generation and the survival of the secondary ions." Liebl et al. thereafter conclude that the survival of the secondary ions, correlated to the electronegativity of the primary sputtering ions, is much more important than the primary ion mass. The Examiner assumes that the combination of Schultz et al. with Liebl et al. would teach a person skilled in the art to use Bismuth instead of gold as a primary ion because the atomic weight of Bismuth is higher than that of gold. Not only does this assumption fly in the face of the fact that both documents fail to mention the use of Bismuth at all, but it fails to take into account that a person skilled in the art would consider the matrix effect to be most important factor in selecting new primary ions for SIMS. Bismuth would not be "obvious to try" as a replacement for the well-established gold based on a purely theoretical consideration of only one single, and even not the most important, parameter (mass). This argument would logically result in using ions other than gold or Bismuth that have an even higher atomic weight. Such a result would not even be taken seriously by anyone skilled in the art.

After arriving at the alleged obviousness of the use of Bismuth clusters with pure mass as primary ions for SIMS, as inferred from a combination of Schultz et al and Liebl et al., the Examiner turns (with hindsight) to Orloff et al., to demonstrate the use of a liquid metal ion source. Although Orloff et al. do disclose a Bi liquid metal ion source as such, they do not guide a person to use Bi clusters as a primary ion source for SIMS. There is simply no relevance of this reference to the present invention.

Conclusion

There is no prior art which teaches that Bi-clusters are suitable as primary ions in SIMS and there is no indication in the prior art that not only its mass and charge state, but also its chemical properties, make Bi-clusters particularly suited as primary ions in SIMS.

As explained above, the individual references teach away from the present invention so that their combination could not possibly suggest the invention. Indeed, the principal reference (Schulz et al.) is so far afield from the present invention, since it concerns MALDI, that a person skilled in the art would not consider its teaching as being relevant at all to a primary ion source for SIMS.

This application is therefore believed to be in condition for immediate allowance. A formal Notice of Allowance is accordingly respectfully solicited.

Respectfully submitted,

By ____________________
Karl F. Milde, Jr.
~~Reg.~~ No. 24,822

Eckert Seamans Cherin
& Mellott, LLC
U.S. Steel Tower
600 Grant Street - 44^{th} Floor
Pittsburgh, PA 15219-2788

(412) 566-6000

Direct: (914) 286-2819